PATENT SPECIFICATION

(11) 1 496 633

1 496 633

(21) Application No. 8581/76 (22) Filed 3 March 1976
(31) Convention Application No. 2515753
(32) Filed 10 April 1975 in
(33) Federal Republic of Germany (DT)
(44) Complete Specification published 30 Dec. 1977
(51) INT CL² F28D 5/00
(52) Index at acceptance
F4U 13A

(19)

(54) HEAT PIPE

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German company of Berlin and Munich, Germany (Fed Rep), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a heat pipe.

Figure 1 shows a conventional heat pipe in longitudinal cross-section. In this heat pipe, a hollow chamber formed by a cylindrical capillary wick 1, bears at the internal surface of encasing walls 2 of the heat pipe, and defines therewithin a chamber 3. The interior of the heat pipe is evacuated and is filled with a small quantity of a vaporisable working fluid, for example water or alcohol. One end of the heat pipe is put into contact with a source of heat, for example a hot component or structural member 4 from which heat is to be discharged. The opposite end of the heat pipe is cooled, as indicated by the cooling ribs 5. In the zone of the hot component 4 there forms a vaporisation section. In this section, the working fluid vaporises in the wick 1 and the vapour enters the chamber 3. In the zone of the cooling ribs 5, a condensation section forms. In this section, the vaporised working fluid condenses and is drawn into the wick 1. Since the vapour pressure in the zone of the vaporisation section is, thus, higher than in the zone of the condensation section, the vapour molecules travel from the vaporisation section in the direction towards the condensation section. At the same time the working fluid which has condensed in the condensation section flows, due to the capillary action of the wick, back into the vaporisation section so creating a circular fluid flow.

In known heat pipes, the wicks 1 are designed as gauzes, felts or sintered layers having, over the entire layer thickness, a homogeneous structure of substantially uniform pore size. A heat pipe has also already been proposed in which special free ducts, so-called "arteries", are provided for the reflux. For liquids such as water or alcohols, these so-called "artery heat pipes" are unsuitable, since the flow-back of the working fluid into the free ducts is blocked by vapour-bubble formation.

According to the present invention there is provided a heat pipe having a hollow chamber formed by a capillary wick, the inside of which wick defines a chamber for a working fluid, wherein the wick comprises a first, outer layer which is formed from a plurality of layers of gauze and a second, inner layer bounding the chamber formed from a layer of gauze having a smaller mesh than the layers of gauze forming the first layer.

In the wick, the small apertures make high capillary pressure differences possible and therewith good transport capacity of the vapour, whereas the larger apertures have a low resistance to flow-back of the condensed working fluid.

Preferably, the mesh size of the second layer is less than half the mesh size of the first layer.

The first layer may be provided over at least part of its outer surface with a further layer of gauze having a smaller mesh than the layers of gauze forming the first layer.

Since the wick is made of a gauze, the apertures in the gauze will generally be substantially square. The term "aperture size" should therefore be understood to mean the length of one side of the apertures.

The mesh of the first layer may have an aperture size of from 0.1 mm to 1 mm, and preferably an aperture size of substantially 0.5 mm.

The mesh of the second layer may have an aperture size of from 5 μm to 100 μm. Preferably they have an aperture size of substantially 20 μm or substantially 25 μm.

For a better understanding of the present invention, and to show how it may be carried into effect reference will now be made, by way of example, to Figure 2 of the accompanying drawings. In the drawings:

Figure 1 is a longitudinal section of a conventional heat pipe; and

Figure 2 is a transverse section of a heat pipe illustrating two arrangements according to the present invention respectively on the right and left hand sides of the centre line.

In the embodiment illustrated in Figure 2, a heat pipe is made up of an encasing wall 2 along the inner wall of which is diposed a cylindrical wick. The wick defines therewithin a chamber 3 for the working fluid vapour. The heat pipes operate in the manner already described with reference to Figure 1. In each case the wick is formed from two coaxial layers the inner of which has apertures which are smaller than those of the outer layer.

Figure 2 shows two examples of embodiment according to the invention, in which the wick arranged within the wall 2 comprises a plurality of layers of a gauze 6 and an inner layer of a gauze 7 having a smaller mesh than the gauze 6. In the case of the embodiment shown in the left hand half of Figure 2, there is also provided between the wall 2 and the wick a further layer 10 of a gauze having a smaller mesh than the gauze 6.

Such a wick is especially readily manufactured. When manufacturing such a wick, one or two pieces of the smaller mesh gauze will be fitted to one end or to both ends of a strip of the larger mesh gauze to form a tape. The entire tape is then wound on a mandrel the diameter of which is smaller than the internal diameter of the heat pipe. The wound-on tape is then inserted into the heat pipe and bears closely against the wall 2. When employing water as working fluid, gauzes manufactured from phosphor-bronze have been found to be especially corrosion-resistant. Such gauzes prepared from phosphor bronze can be manufactured in particular also with an extremely large number of mesh per surface unit.

The selection of suitable mesh sizes for the layers of the wick should take into account the physical properties of the working fluid. The apertures in the larger mesh layer should be as large as possible. However, the aperture size is limited in the upward direction because as the aperture size increases the risk of the apertures being blocked by vapour bubbles also increases. On employing water as working fluid, an aperture size is advantageous which is between 0.1 mm and 1 mm, preferably at approximately 0.5 mm.

The apertures of the smaller mesh layer should be as small as possible, so as to generate maximum capillary force. The aperture size is limited in the downward direction by the ability to prepare small aperture layers. On employing water as working fluid, there have been found advantageous for the smaller aperture layer or layers aperture sizes of between 5 μm and 100 μm. A practical aperture size is one of approximately 25 μm.

The selection of layers having suitable aperture sizes will, within the said limits, be determined also by manufacturing considerations. The essential factor is that the ratio of the aperture sizes of the large aperture layer to the small aperture layer is as large as possible.

In use of the heat pipe the large apertures prevent blocking of the transport section due to vapour bubble formation. The large apertures afford, by comparison with small apertures, a substantially larger free flow cross-section offering only slight resistance to flow back of the condensed working fluid. On the other hand, the small capillary pressure difference in the case of large apertures is not disadvantageous since the capillary force set up at the boundary face between the wick and the vapour chamber is supplied by the second, small aperture layer arranged at this location.

The quantity of heat dischargeable with a heat pipe according to the invention can be increased relative to heat pipes having homogeneous wick structure by a factor corresponding approximately to the ratio of the aperture size of the large aperture layer to the small aperture layer. the ratio of the aperture sizes relative to each other can, thus, be determined by the desired capacity increase relative to a known heat pipe wherein the wick having a homogeneous small aperture structure is provided.

In comparison with heat pipes having a homogeneous small aperture wick structure, for the same quantity of discharged heat, heat pipes according to the invention may be longer and/or thinner and operate more satisfactorily against gravity. Additionally, there is greater freedom with regard to the selection of working fluid.

WHAT WE CLAIM IS:—

1. A heat pipe having a hollow chamber formed by a capillary wick, the inside of which wick defines a chamber for a working fluid, wherein the wick comprises a first, outer layer which is formed from a plurality of layers of gauze and a second, inner layer bounding the chamber formed from a layer of gauze having a smaller mesh than the layers of gauze forming the first layer.

2. a heat pipe as claimed in claim 1, wherein the mesh size of the second layer is less than half the mesh size of the first layer.

3. A heat pipe as claimed in claim 1 or 2, wherein the first layer is provided over at

least part of its outer surface with a further layer of gauze having a smaller mesh than the layers of gauze forming the first layer.

4. A heat pipe as claimed in any preceding claim, wherein the mesh of the first layer have an aperture size (as defined herein) of from 0.1 mm to 1 mm.

5. A heat pipe as claimed in claim 4, wherein the mesh of the first layer have an aperture size of substantially 0.5 mm.

6. A heat pipe as claimed in any preceding claim, wherein the mesh of the second layer have an aperture size of from 5 μm to 100 μm.

7. A heat pipe as claimed in claim 6, wherein the mesh of the second layer have an aperture size of substantially 20 μm.

8. A heat pipe as claimed in claim 6, wherein the mesh of the second layer have an aperture size of substantially 25 μm.

9. A heat pipe substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

HASELTINE, LAKE & CO.,
Chartered Patent Agents,
Hazlitt House,
28, Southampton Buildings,
Chancery Lane,
London WC2A 1AT
also
Temple Gate House,
Temple Gate,
Bristol BS1 6PT
and
9, Park Square,
Leeds LS1 2LH,
Yorks.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1496633 COMPLETE SPECIFICATION

1 SHEET This drawing is a reproduction of the Original on a reduced scale

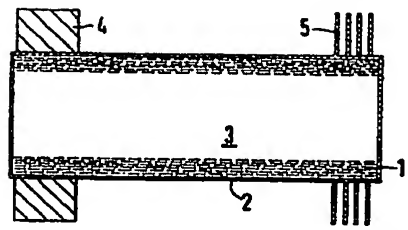

Fig.1

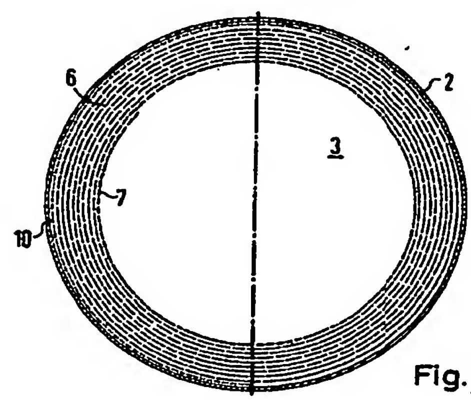

Fig.2